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*Published in:*
Proceedings of the 9th International Meeting on Low Frequency Noise & Vibration

*Publication date:*
2000

Aalborg 2000
Low Frequency Noise and Vibration

9th International Meeting
17th-19th May, 2000
Aalborg, Denmark
Proceedings edited by
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# Complaints of infrasound and low-frequency noise studied with questionnaires

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## Summary

A survey of complaints about infrasound and low frequency noise has been carried out. 167 persons reported about their annoyance in a questionnaire. Their verbal reports often describe the sound as deep and humming or rumbling, like coming from a distant idling engine of a truck or pump. Nearly all respondents report of a sensory perception from the sound. In general they report that they perceive it with their ears, but many mention also a perception of vibrations, either in their body or of external objects. The sound disturbs and irritates during most activities, and many consider its mere presence as a torment to them. Many of the respondents report on secondary annoyance in terms of various kinds of unpleasantness (e.g. insomnia, headaches, palpitation), which they associate with the sound mainly because it occurs at the same places as the sound. In a majority of the cases, only a single or few persons can hear the sound, but there are also examples where it is claimed to be audible to everybody. Typically, measurements have shown that existing limits (and hearing thresholds) are not exceeded. The investigation leaves the key question: Is the annoyance induced by an external sound or not, and if it is, which frequencies and levels are then involved. The feasibility of a study of this is supported by the results.

## Introduction

For many years there have occasionally been cases where people complain about infrasound or low frequency noise. This is the case in Denmark, and probably the situation is comparable in many other countries. Most descriptions mention a deep humming sound in the home of the complainant, which annoys and disturbs sleep, rest and concentration. In addition, the sound is often claimed to cause an impaired quality of life due to headache, pain, stress, and other kinds of unpleasantness, including severe worries of being exposed to a 'mysterious sound'.

Typically, the sound is only perceived by a single person and not the entire household. For this reason, among others, it is often proposed that it is doubtful to consider the problems as induced by an external, physical sound. As a consequence, in most cases no action is taken, and the complainant is left alone with his or her problem. Many of the annoyed persons find this situation unacceptable, and in Denmark some of these have organized themselves in a society, "Enemies of Infrasound" ("Infralydens fjender"). The society puts a constant pressure on the authorities by repeatedly bringing up their problem, e.g. in the press.

A disturbing matter is the widespread misunderstanding that infrasound is inaudible for humans, because the frequency components are placed below the *'audible frequency range'* from 20 Hz to 20 kHz. Although it was shown at least as early as in the 1930'es that infrasound can be perceived, when only the sound pressure level is sufficiently high ([1], [2], [3]), this misunderstanding still exists, even among professionals. As a consequence, the mere mention of the word *infrasound* brings up associations to 'inaudible sound', which is hardly worth to take seriously.

**Official initiatives in Denmark.** In 1995 the Danish Environmental Protection Agency arranged noise measurements in some selected cases. The measurements usually showed sound pressure levels well below or, at the highest, around the normal hearing threshold for low and infrasonic frequencies, a fact that added to the skepticism towards the complainants. The hypothesis was put forward that they might suffer from a special low frequency tinnitus, but this was never confirmed.

Also in 1995 the Danish National Board of Health took the initiative to form a group of general physicians, epidemiologists, audiologists and engineers to consider the situation. The group soon realized that the most urgent matter was to clarify, whether the annoyance was really induced by an external sound or not, and if it was, which frequencies and levels were involved.

The group planned a research program, which included a detailed investigation of 20 selected cases. The program would comprise sound measurements and calibrated recordings at the places of the claimed exposure. Each recording would subsequently be played back in the laboratory to the actual complainant, using a pattern of blind tests to see whether the sound could be heard and recognized. Also playback of filtered recordings was planned in order to encircle the frequencies responsible for the annoyance. The playback was planned to take place at Aalborg University, thus taking advantage of exposure facilities, which cover both the infrasonic and low frequency range. Furthermore, all complainants would have a general medical check and undergo detailed audiological and vestibular examinations, including examinations at low and infrasonic frequencies.

Unfortunately, due to disagreement about the financing between the National Board of Health and the Environmental Protection Agency, the proposed program was never accomplished. Soon after it had been given up, the Environmental Protection Agency issued an information report on low frequency noise, infrasound and vibrations [4]. The report recommends that the indoor noise in dwellings should not exceed 85 dB(G) for the infrasound and 20 dB(A) for the low frequency noise up to 160 Hz. For frequencies below 20 Hz these limits guarantee a sound pressure level approximately 10 dB lower than the average hearing threshold. Going towards higher frequencies, the limit passes the average threshold around 30 Hz (ISO 389-7 [5]), and a level 10 dB above the average threshold is reached around 70 Hz. These limits appear quite reasonable, provided that they are used with measurements that truly represent the human exposure. On the other hand, it seems that in most of the cases, which initiated the information report, measured levels are below these limits, and the report apparently stopped further examination of these cases.

(The information report [4] states that the limit is 10 dB below the average hearing threshold up to 40 Hz. This is not true; the 'average hearing threshold' used to show this is the average of a few investigations of which some are clearly doubtful in the 25-50 Hz range).

**The present situation.** It is a fact that our knowledge of low frequency hearing is based on a few investigations with a limited number of subjects, and it cannot be excluded that there are individuals with a much better or otherwise deviating hearing at these frequencies. If this is the case, it might not justify a lowering of the general limits, but a better understanding might lead to tools and solutions that could alleviate the annoyance in specific cases. It is characteristic for many cases that the annoyed person, or even an alleged 'noise polluter', is not unwilling to pay for a solution, if he or she only knew what to do.

It is no secret that the authors of the present paper find it unsatisfactory that the investigation proposed by the National Board of Health group was given up. We are well aware that the investigation might show that the annoyance is induced by physical sound in only few or even none of the cases. Even that would be a valuable result, though, since it would pave the way for a constructive search for other possible reasons. The uncertainty which is still connected to the matter has irrational consequences, e.g. power plants and factories being accused of 'polluting' entire regions with noise, worries about effects of sound based on pure speculation, worries that house prices will go down in 'polluted' areas etc. There are even examples of local authorities who have abstained from investigating straightforward cases of noise complaints with reference to these problems.

We have often been tempted to carry out the laboratory blind tests on our own expense. However, we have intentionally refrained from starting this, since we would only be able to examine a small group of complainants. We imagine that there may be a variety of reasons for the complaints, and there would be a high risk of making wrong conclusions from an insufficient investigation.

**Present study.** The survey presented in this paper is the result of a persistent pressure of 'at least doing something' from "Enemies of Infrasound", consulting acousticians, and some civic and regional authorities dealing with noise—as well as of our own curiosity. It has been the intention among other things to clarify, whether the annoyance experienced by different people is similar and what it is, whether there are reasons to believe that the annoyance is induced by physical noise or not, where and when the problems occur, whether problems occur all over the country, and what has been done to solve the problems. The present paper summarizes some important results of the survey.

## Design and distribution of the questionnaire

The questionnaire was printed on nine sheets of A4 paper and included an instruction and 45 numbered questions. It was prepared in such a way that the annoyed person could fill it out directly, or a family member or case officer could do it, e.g. via an interview. The cover letter recommended that the annoyed person did it personally. Most of the questions were structured in a multiple-choice form. A few questions required text to be entered.

**Instructions**. The respondents were encouraged to add comments in the large margins of the sheets, if the multiple choice possibilities did not offer the relevant answer. It was pointed out that they were allowed to abstain from answering some of the questions, and that it was legal to give more than one answer in a question if appropriate. For these reasons the percentages of answers in a multiple-choice list will not necessarily sum up to 100%.

Depending on the situation and the answers given, some of the 45 questions would be irrelevant for some people. For this reason the respondents were sometimes told to skip

questions and go to a subsequent question, depending on the answers already given. Some people were obviously too eager in answering the questions and did not make the correct jumps. These were kindly asked to fill out a new questionnaire, unless the error could be rectified in the data processing without any risk of misinterpretation.

**Distribution**. Questionnaires were sent to civic and regional environmental administrations throughout the country, to the secretariat of "Enemies of Infrasound" and to a number of acoustic consultants in Denmark. It was furthermore available in PDF-format from the internet homepage of the Department of Acoustics, Aalborg University. People were encouraged to copy and distribute it freely.

Because of the distribution form, it is not known how many copies that were actually distributed, and the responses cannot be used to estimate the number of annoyed persons, the geographical distribution of the problems, or any similar statistics. As an example of an odd distribution, clearly more responses were obtained in the region close to the secretariat of "Enemies of Infrasound" than from other regions. This might indicate more problems in this region, but more likely it demonstrates the society's success in using the press to make people aware of the survey (and of the problem). The responses must simply be taken as examples of cases where a person has a problem, which he or she believes is associated with low frequency noise or infrasound.

171 questionnaires were returned, most of these within the first months following the launch of the campaign in August 1998. 4 persons did not respond to a request of clarification in connection with incorrect jumps, thus leaving 167 responses for analysis.

## Questions and Results

Almost all questionnaires were filled out by the annoyed person and only a few were filled out by family members or case officers. About two thirds of the respondents were female and one third was male. The only well established evidence of women having a better hearing than men is at high frequencies, where the impairment of hearing with age differs between genders (ISO 7029:1984 [6]). Even though the similarity of hearing between genders has not been fully confirmed at very low frequencies, the difference in number of respondents is more likely caused by social or psycho-social reasons.

Questionnaires were received from all over the country. Large and small cities as well as the countryside were represented. The respondents were between 14 and 86 years of age with a mean of 55.6 years.

**Individual's description of the sound**. In the first question that was not just of a formal nature, the persons were asked to describe the sound in their own words, and eight blank lines were left for this purpose. Most of the respondents tried eagerly to give a detailed description of the sound. Naturally, there is a large variety in the answers but some expressions are frequently used, such as the sound....

....is a deep humming/rumbling sound,
....is constant and unpleasant,
....creates a pressure in the ears,
....affects the whole body,
....sounds like coming from a large (idle running) engine of a truck, pump, ferry or aircraft,
....is coming from somewhere far away, outdoor, and may be transmitted through the ground.

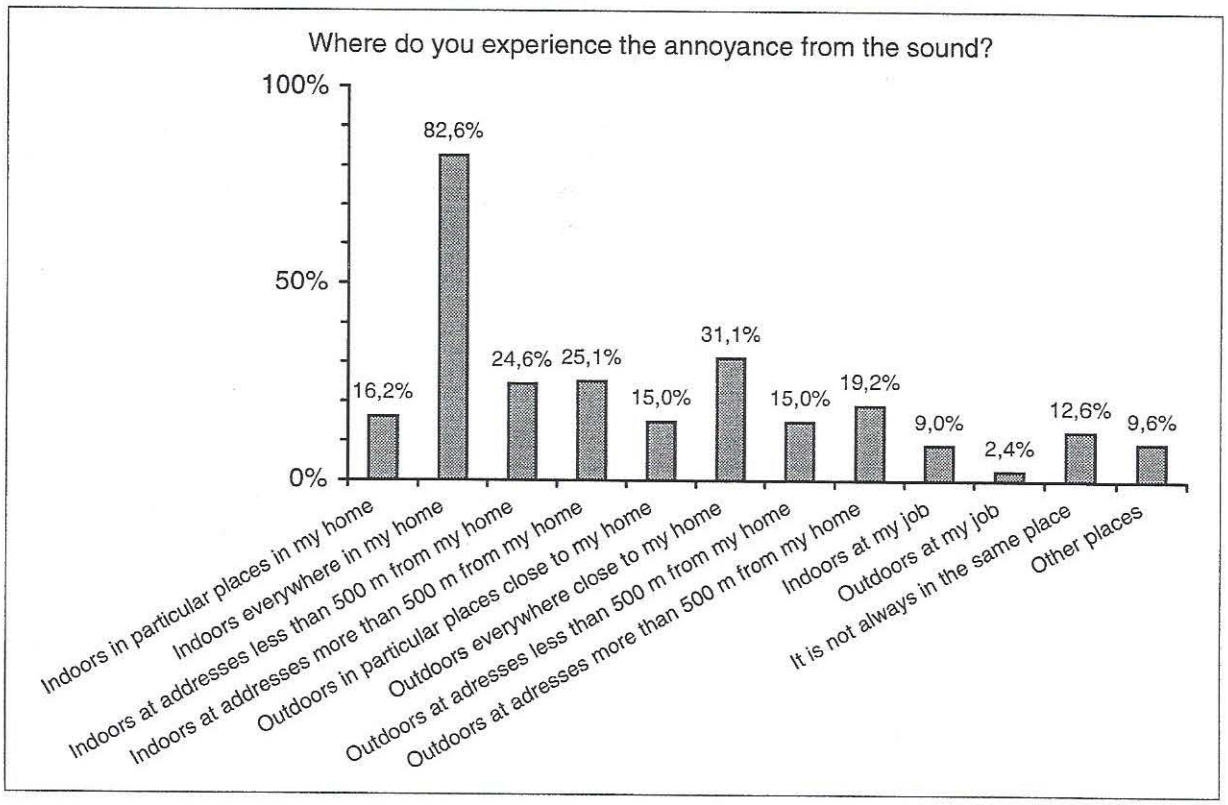


*Figure 1. Question 6, places where the annoyance occurs. Rates of answers given in percentage of all respondents.*

Many persons are apparently not able to localize the sound source directly. Therefore they make a number of speculations on what may be the source. The impression of the source being far away and outside the house may be caused by lack of midrange and high frequencies. Then our common experience from sound transmission through walls and over long distances could create the illusion of a distant source, even if the sound is actually generated nearby.

**Where and when the annoyance occurs**. In one question the persons were asked where they experience the annoyance. The responses in terms of statistical frequencies are shown in Figure 1. It is seen that nearly all of the persons are annoyed indoors in their home, either all over the home (82.6%) or at particular places (16.2%). Furthermore it is seen that the annoyance is experienced not only inside buildings, but also sometimes outside. Only few problems are seen at the job. Many people added margin comments on extra details like where in the home the sound is most intense, how their experience is at other places etc.

In another question the persons were asked which time of the day the annoyance occurs. The answers were almost equally distributed between day, evening and night, however with a small preponderance in the nighttime (22:00-7:00). A vast majority marked two or three of the three intervals.

**Is the sound perceived with the senses?** As mentioned, it has often been argued that some of the complainants might not actually *hear a sound*, but rather feel some general unpleasantness and put the blame on sound, only because of rumors about strange effects of infrasound and low frequency noise. In one question the persons were asked, whether they perceive the sound directly with their senses. In order not to bias the persons towards

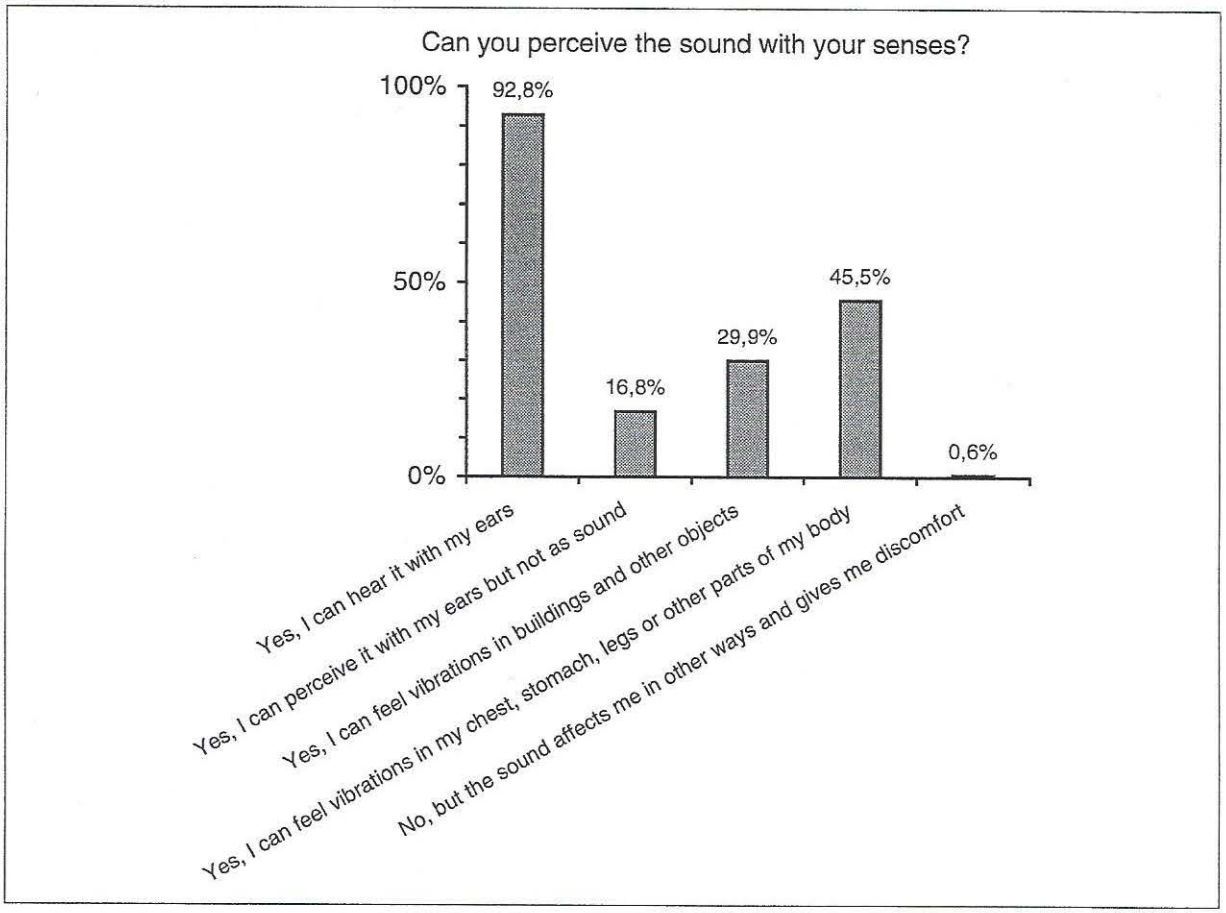


*Figure 2. Question 7, sensory perception. Rates of answers given in percentage of all respondents.*

reporting a false sensory perception, the wording of the question and the possible answers were carefully selected in order to make it perfectly 'legal' and not in any way doubtful to admit that the sound was not directly perceived.

The results of this question are given in Figure 2. It is seen that nearly all persons (92.8%) report that they hear a sound with their ears. Some persons (16.8%) report of a sensation in the ears apart from a sound. 97.6% answered one or both of the two first categories, thus nearly all respondents have a sensory perception related to the ears. Large parts of the persons have a sensation of vibrations, either in their body (45.5%) or of objects around them (29.9%).

Only 0.6% (a single person) did not report of a direct sensory perception. This person reported insomnia and headache, and as a reason for blaming infrasound or low frequency sound, the person reported that he or she had heard or read that it might be the reason.

In one question the persons were asked how long time they have to be in the sound before the annoyance occurs. Results from this question are given in Figure 3. Obviously, the annoyance starts very soon for most of the persons, as 64.7% indicate "immediately" and 23.4% state "within a few minutes" (a few persons reported both of these answers, thus 85.0% answered at least one of them). The immediate occurrence of the annoyance corresponds well with the direct sensory perception.

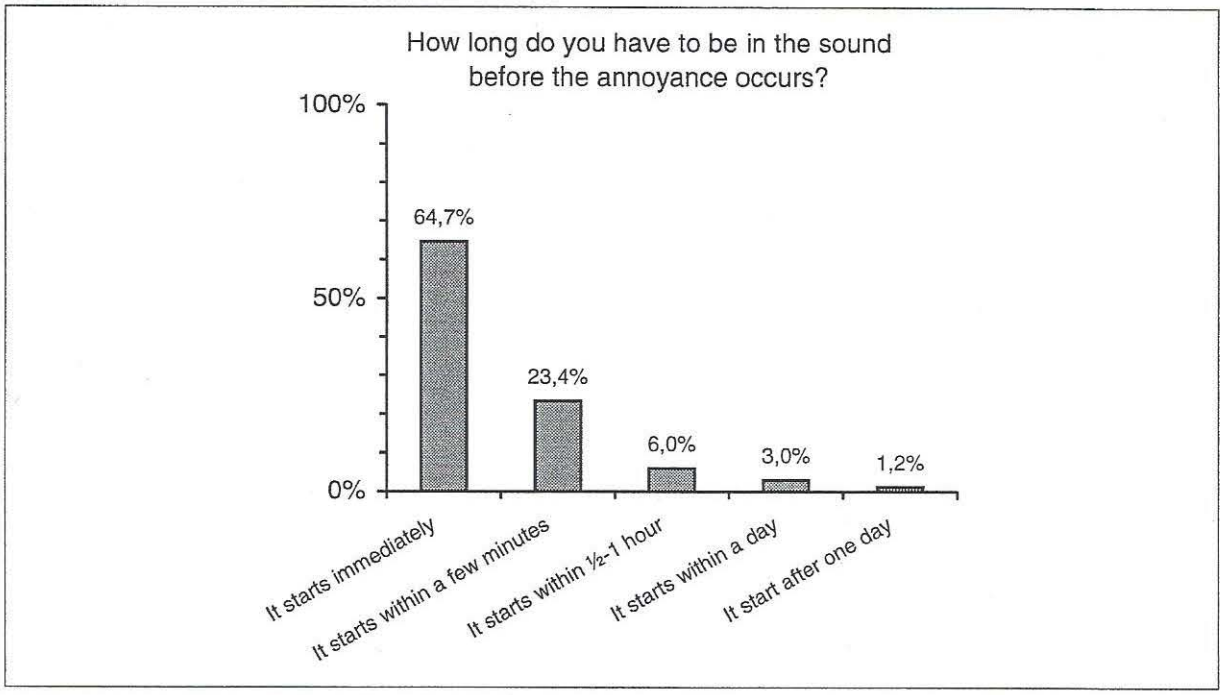


*Figure 3. Question 28, time before annoyance occurs. Rates of answers given in percentage of all respondents.*

**Can other people hear the sound?** The persons with a reported direct sensory perception were asked whether other people are able to perceive the sound as well. The results from this question are shown in Figure 4. 39.6% reported that he or she is the only person who can hear it, while 27.7% indicated that a few persons can hear it. Only 17.0% indicated that the sound is audible to everybody.

Some persons added extra information on exactly who can hear the sound, or mentioned that he or she lives alone and does not have visitors very often. In such cases there may be a bias in the answers, since more persons than indicated might be able to hear the sound, if only other people were being exposed to it.

In another question the persons were asked, whether other people had mentioned the sound without being made aware of it. This had happened in 39.0% of the cases.

**Kinds of annoyance**. The persons with a sensory perception were asked which kinds of annoyance that are related to the sound. The question was split up into primary annoyance, i.e. annoyance directly related to the perception, and secondary annoyance, i.e. other kinds of unpleasantness believed to be induced by the noise.

The answers from the question concerning primary annoyance are seen in Figure 5. A majority of the persons reported on problems like being disturbed when falling asleep or when reading, frequently paying attention to or being irritated by the sound, and being awakened from sleep. 78% consider the mere presence of the sound as a torment to them. An example from the "Others" category is pressure in the ears.

The answers concerning secondary annoyance are seen in Figure 6. The highest rates (around 70%) occur for insomnia and lack of concentration, unpleasantness which is nearly 'primary'

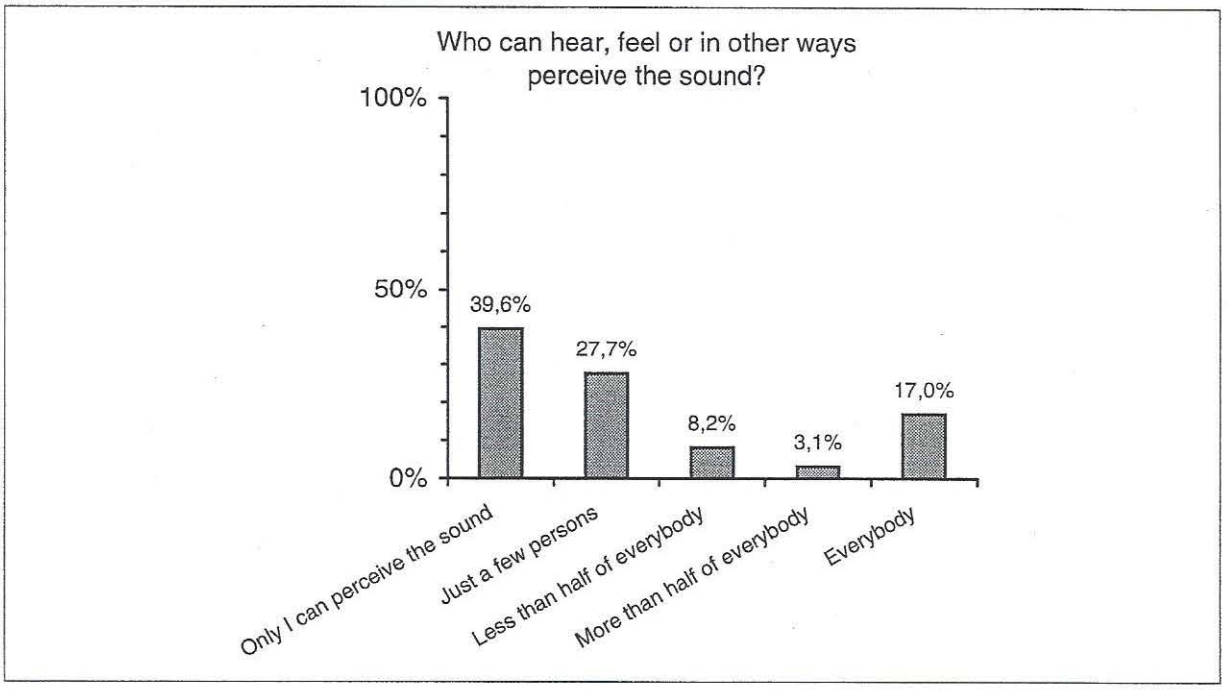


*Figure 4. Question 14, number of persons who can perceive the sound. Rates of answers given in percentage of respondents with claimed sensory perception.*

and which was more or less reported already in response to the question on primary annoyance. As examples of truly 'secondary' effects, large groups reported dizziness, headaches and palpitation. Examples from the "Others" category are stress, aggression, restlessness, nausea, fatigue, increased tension in muscles, and weak nerves.

Those persons who indicated secondary annoyance were asked why they believe infrasound or low frequency noise is responsible. 79.7% of them relate the secondary annoyance to the sound because it appears at the same places. Quite many (38.5%) indicate that they have heard or read that the unpleasantness may be induced by sound.

**Attempts to improve the situation.** In one question the persons were asked what they have done in order to relieve the annoyance. Quite many have tried to use earplugs at night (64.2%) or during the day (37.7%), most often without any effect. 9.4% have moved to another house, and 52.8% consider doing it. 42.8% have consulted their general practitioner or a specialist, and 17.6% take medicine.

**Complaints to authorities.** 64.2% of the responding persons have complained to the authorities about the noise. In 15.9% of these cases the complaint was rejected immediately. In 63.5% an official person has visited the complainant or an address in the neighborhood in order to evaluate the situation.

Noise measurements have been made in 49.5% of the cases in which an official complaint was filed, vibration measurements in 10.2%. Typically, measurements did not reveal anything that was expected to give rise to problems (or be audible), and existing limits were usually not exceeded. (This refers to the explanations given by the annoyed persons; the authors have not had the opportunity to study the original measurement reports). Measurement difficulties are frequently reported, e.g. because of background noise or insufficient equipment. Some of the persons have expressed their distrust in the measurements and the limits.

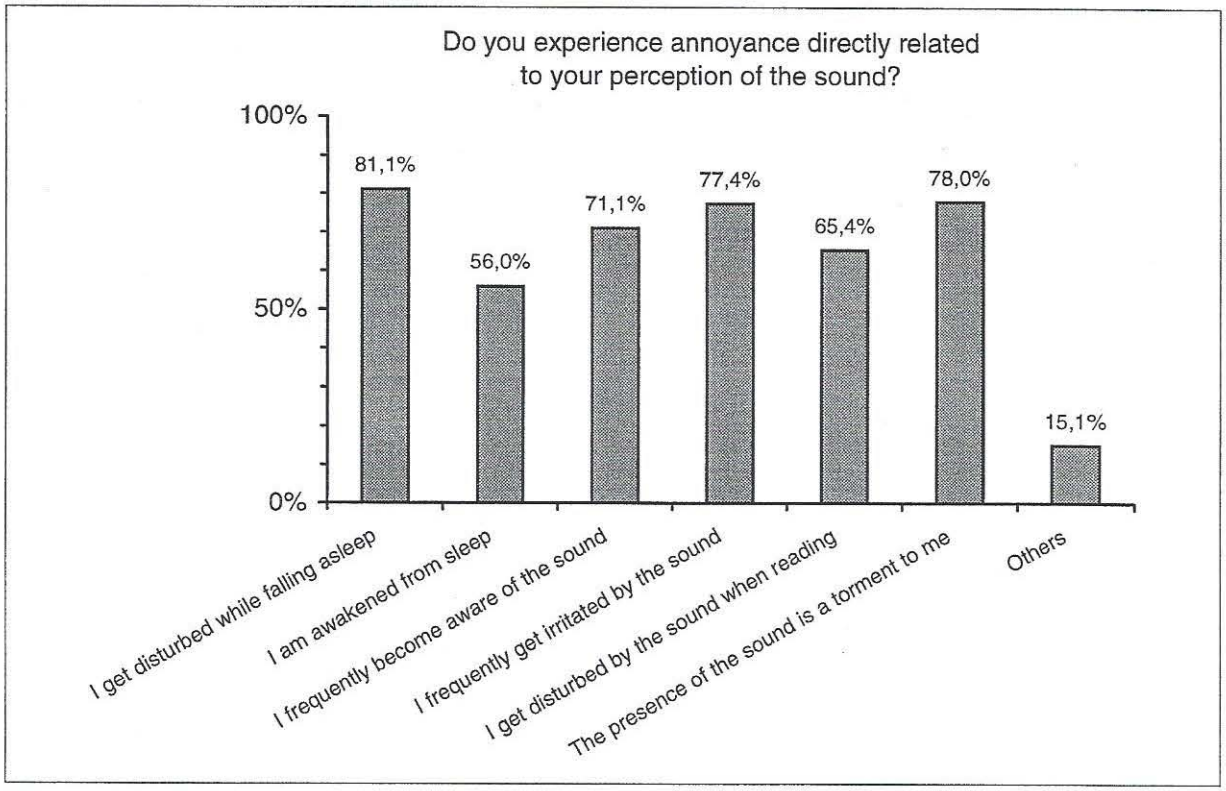


*Figure 5. Question 16, primary annoyance. Rates of answers given in percentage of respondents with claimed sensory perception.*

Only 8.4% of those who have complained to the authorities feel that their problem has been solved or partly solved. However, in an investigation like the present, there will be a natural bias towards a low number of persons for whom the problems have been solved, since these persons will be less motivated for filling out a questionnaire than those who still have a problem.

## Conclusion

The 167 respondents experience the annoyance mainly in and around their homes. Their verbal reports often describe the sound as deep and humming or rumbling, like coming from a distant idling engine of a truck or pump. Nearly all respondents report of a sensory perception from the sound. In general they perceive it with their ears, but many have also a perception of vibrations, either in their body or of external objects. The sound disturbs and irritates during most activities, and many consider its mere presence as a torment to them. Many of the respondents report on secondary annoyance in terms of various kinds of unpleasantness (e.g. insomnia, headaches, palpitation), which they associate with the sound mainly because it occurs at the same places as the sound. In a majority of the cases, only a single or few persons can hear the sound, but there are also examples where it is claimed to be audible to everybody.

There are respondents from all over the country, however with a preponderance in the area where "Enemies of Infrasound" has been particularly active. There are more women than men among the respondents. Many of the respondents have complained to the authorities, but most often this has not led to a solution. Typically, measurements have shown that existing limits are not exceeded. Sometimes authorities have rejected cases immediately. The study is most

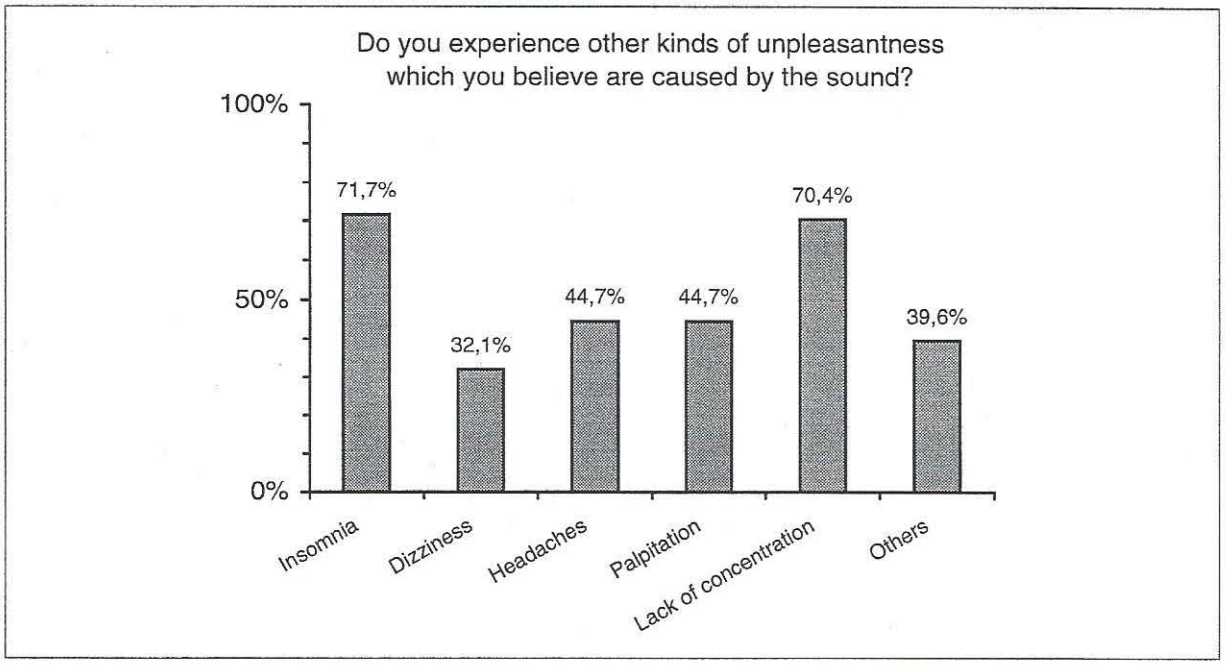


*Figure 6. Question 17, secondary annoyance. Rates of answers given in percentage of respondents with claimed sensory perception.*

likely biased towards having unsolved cases, since people with solved problems are less motivated towards submitting a questionnaire. Because of the simple distribution form of the questionnaire, the result of the investigation cannot be used to estimate the extent of low frequency problems in the country, but the cases must be regarded as examples only.

Even when the respondents report a sensory perception, this perception does not have to be induced by an external sound exposure. An investigation previously proposed by the National Board of Health group is needed more than ever as a means in clarifying whether external sound is responsible, and if so, which frequencies and levels are involved. The fact that most of the respondents report that the annoyance starts very soon after they are exposed, is further motivating, and it will facilitate the design of blind tests.

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